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APPLICANT : SKY ALUM CO LTD;

INVENTOR : TAGATA TSUTOMU;

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TITLE : ALUMINUM ALLOY PLATE FOR SUPER PLASTIC FORMING, ALUMINUM ALLOY TUBE AND ITS SUPER PLASTIC FORMED BODY

ABSTRACT : PROBLEM TO BE SOLVED: To obtain a wide width aluminum alloy plate for super plastic forming and to integrally form a large formed body by subjecting rolled plates of super plastic aluminum alloy each other to solid-state welding.

SOLUTION: Solid-state welding is a joining method not remaining a solidified structure to a joining part. It is preferable for solid-state welding to use friction agitation welding, flash butt welding, DC butt welding, resistance welding. A super plastic aluminum alloy is either of Al-Mg alloy, Al-Zn-Mg alloy, Al-Zn-Mg- Cu alloy, Al-Cu alloy, Al-Li alloy, Al-Mg-Si alloy, Al-Si alloy, etc., a recrystallization grain is refined, a grain size is preferably ≤30 μm. The material, refined by static recrytallization is subjected to a grain refining treatment to have a grain size of ≤40 μm, or a cold rolling of a draft of ≥40% or softening annealing to a degree not generating recrsytallization in a process to produce a rolled plate.

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(71)Applicant : **SKY ALUM CO LTD**

(72)Inventor : **MATSUO MAMORU**
TAGATA TSUTOMU

(54) ALUMINUM ALLOY PLATE FOR SUPER PLASTIC FORMING, ALUMINUM ALLOY TUBE AND ITS SUPER PLASTIC FORMED BODY

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a wide width aluminum alloy plate for super plastic forming and to integrally form a large formed body by subjecting rolled plates of super plastic aluminum alloy each other to solid-state welding.

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CLAIMS

[Claim(s)]
[Claim 1] The double width aluminum alloy plate for superplastic forming characterized by carrying out solid state welding of the super-elasticity aluminum alloy rolled plate comrade.
[Claim 2] Aluminum alloy tubing for superplastic forming with which it comes to carry out solid state welding of the super-elasticity aluminum alloy rolled plate.
[Claim 3] Claim 1 characterized by using friction stirring junction, flash butt welding, DC butt welding, and electric resistance welding as solid state welding, and super-elasticity aluminum alloy material according to claim 2.
[Claim 4] The super-elasticity Plastic solid which comes to carry out superplastic forming of the zygote according to claim 1 or 2.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is really [large-sized] applied to the structures, such as ornament applications, such as mold goods and building materials, and an automobile, a bridge, a cross-section variant pipe, etc. about the double width alloy plate which consists of a rolled plate of the aluminum alloy for superplastic forming, i.e., the aluminum alloy which performs a fabricating operation at 300-560 degrees C, or alloy tubing, and its Plastic solid.
[0002]
[Description of the Prior Art] In recent years, various researches are made about the superplastic materials in which 100% or more of elongation is shown at an elevated temperature 350 degrees C or more in an aluminum alloy, and aluminum-Mg alloys, such as aluminum-78%Zn, aluminum-33%Cu, and aluminum-6%Cu-0.4%Zr (SUPURAL), an aluminum-Zn-Mg-Cu alloy (7475 7075), and 5083, etc. are known as a super-elasticity alloy. From the elongation which reaches also to several 100% being acquired, a complicated Plastic solid and the structure by it are proposed, and these super-elasticity alloys are put in practical use. Moreover, since the description of superplastic forming is fabricated at an elevated temperature, it is that can deform with low stress, and generally it is fabricated by blow molding. Therefore, metal mold does not have the need for high intensity superhard construction material only at a female like the cold pressing [good in many cases and] of metal mold general in construction material, and it is one of the big descriptions that metal mold expense is cheap. Its effectiveness is large when such superplastic forming is applied to one shaping of the large-sized mold goods to which metal mold expense moreover increases by inside with comparatively few products - the little form, for example, a leisure boat, etc.
[0003] Moreover, it is also requested that superplasticity forming is applied to tubing and the shell or the structure which has a complicated cross section is fabricated, a circle or corniform tubing is beforehand manufactured by extrusion in this case, and, generally it is proposed that carry out the seal of the ends of this tubing, and they carry out superplastic forming by blow molding etc.
[0004]
[Problem(s) to be Solved by the Invention] However, although the rolled plate large-sized as a raw material was required in order to obtain large-sized mold goods by the superplastic forming mentioned above, the large-sized rolled plate, especially the double-width rolled plate had the constraint on a facility actually, and there was a limitation in double width-ization. Although it is possible as a cure for this to usually weld a plate, since it once dissolves and a

weld zone serves as solidification structure, the super-elasticity property of this part has the problem of disappearing thoroughly. Moreover, since superplastic forming is generally based on blow molding, if a crack and fracture have arisen by poor welding even in the piece place, air leakage will occur and shaping of it will become impossible. Therefore, double-width-izing by welding is impossible.

[0005] Moreover, in manufacturing tubing, there are 5083 and 7475 grades which were mentioned above as an alloy which discovers super-elasticity, but these are alloys with very difficult extrusion in many cases, and since cold drawing of the extrudate is carried out, it is [that it is hard to perform performing and carrying out grain refining of the thermomechanical treatment therefore] still more difficult [extrudate] to give sufficient super-elasticity property.

[0006] However, in order to advance enlargement of a super-elasticity Plastic solid, the double width of the ingredient in which superplastic forming is possible, and enlargement are indispensable, and the junction approach that the super-elasticity property of a joint does not fall for that purpose needs to be developed. Moreover, if the superplastic forming of tubing becomes possible, creation of the variant pipe which has the complicated cross-section configuration used for an automobile as shown in drawing 1 is attained, and superplastic forming also opens the application of the ornament column for building materials which has a complicated surface pattern from excelling in imprint nature. for this reason -- being also alike -- possible aluminum alloy tubing of superplastic forming needs to be manufactured, and a conjugation method without lowering of a super-elasticity property needs to be developed for it.

[0007]

[Means for Solving the Problem] The joint was not dissolution solidification structure but solid state welding wholeheartedly about the conjugation method which does not check a super-elasticity property as a result of research examination, and by giving a lot of possible processing distortion to a joint, detailed crystal grain was obtained with heating at the time of superplastic forming, and the artificer had, examined the ingredient with which the super-elasticity property of a joint does not fall substantially, and the combination of the junction approach, and resulted in the following invention.

[0008] That is, the super-elasticity aluminum alloy rolled plate comrade of this invention is aluminum alloy tubing for superplastic forming with which are the double width aluminum alloy plate for superplastic forming characterized by carrying out solid state welding, and it comes to carry out solid state welding of the super-elasticity aluminum alloy rolled plate. It is the super-elasticity Plastic solid which are claim 1 characterized by using friction stirring junction, flash butt welding, DC butt welding, and electric resistance welding as solid state welding, and super-elasticity aluminum alloy material according to claim 2, and furthermore comes to carry out superplastic forming of the zygote according to claim 1 or 2.

[0009]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained.

[0010] First, the superplastic materials in this invention are explained. Although the ingredient used for this invention is altogether applicable if it is an aluminum alloy in which a super-elasticity property is shown, generally they are an aluminum-Mg system, an aluminum-Zn-Mg system, an aluminum-Zn-Mg-Cu system, an aluminum-Cu system, an aluminum-Li system, an aluminum-Mg-Si system, an aluminum-Si system, etc., and 5083, 7475, and 2004 grades are specifically fundamentally suitable for it. By generally making a recrystallization grain detailed, the super-elasticity aluminum alloy has acquired the super-elasticity property, and its 30 micrometers or less are desirable as crystal grain size. Moreover, two kinds, the static recrystallization type (5083, 7475 grades) which makes crystal grain detailed before

usually performing super-elasticity deformation, and the continuous recrystallization type made to recrystallize dynamically during super-elasticity deformation, are known, and it can use both these static recrystallization type and dynamic recrystallization type in this invention. Even if the ingredient of the type made detailed with static recrystallization performs grain-refining processing at the process which manufactures a rolled plate beforehand, it sets the diameter of crystal grain to 40 micrometers or less. Or it is made to make it recrystallize with heating at the time of superplastic forming as H2n which carried out softening to extent of 40% or more of reduction of sectional area from which cold rolling processing is carried out, and it considers as H1n material, or recrystallization does not produce it, or an H3n condition. By the type which carries out dynamic recrystallization, it is required for the cold rolling plate (H1n) of 40% or more of rates of cold rolling, and extent from which recrystallization does not produce it to consider as H2n or H3n condition which carried out softening, and, thereby, dynamic recrystallization arises and makes it detailed during deformation with the dynamic distortion at the time of super-elasticity deformation, and the relation of temperature.

[0011] The conjugation method in this invention is explained below. As for the conjugation method used by this invention, it is indispensable that it is a solid-state-welding method. Here, it is applicable, if a fusion zone is discharged in a junction process and the junction interface serves as solid state welding as a result, even if a solid-state-welding method means the conjugation method with which solidification structure does not remain in a joint and the dissolution arises in a junction interface temporarily like a flash-butt-welding method. However, in spot welding and spot welding like projection welding, since it is not joined and air leakage is started from here between welding point comrades at the time of shaping, it is not desirable. Solid phase stirring junction (FSW), flash plate vat junction, DC vat junction, electric resistance welding, etc. are common, and, more specifically, especially solid phase stirring junction (FSW) is suitable from a high distortion being introduced into a joint and a super-elasticity property improving.

[0012] The operation by this invention is as follows. Since it becomes the solidification structure where the joint was once fused in the case of fused junction, crystal grain makes it big and rough, and a super-elasticity property is completely lost. On the other hand, even if in the case of solid state welding melting does not happen or it once fuses, molten metal is discharged from a joint, and as a result, the condition that big and rough crystal grain does not exist is acquired by the joint. Furthermore, a high distortion is introduced from receiving strong plastic working in the condition of an elevated temperature [near / a junction interface and / its], therefore detailed recrystallization of the joint is carried out, or it is minutely recrystallized with heating at the time of superplastic forming at least. That is, the super-elasticity property of a joint will be maintained, without falling, or will improve. Consequently, the zygote by this invention becomes possible [giving sufficient shaping by superplasticity forming]. Therefore, by joining two or more narrow-width rolled plates, enough magnitude large-scale super-elasticity plates can be obtained, and it becomes possible by carrying out superplastic forming of this to really fabricate large-scale Plastic solids, such as a leisure boat hull. Or 5083, and the extrusion and drawing like 7475 are able to make tubing also from a difficult alloy system easily by incurvating a rolled plate and joining. And since the super-elasticity property is not lost, it becomes possible to manufacture the tubular Plastic solid of a complicated configuration easily by carrying out tube expanding of this tubing by superplastic forming using variant cross-section metal mold.

[0013] In addition, there is no generating of the clearance from which a gas although a gas will leak at the time of superplastic forming if it is easy to produce a crack etc. in a joint as a weld flaw in fused junction and there is such a crack, and fabricating becomes difficult, since it joins putting a pressure high in solid state welding leaks, and there is no problem at the time of such shaping.

[0014] Moreover, in manufacture of tubing, cold drawing may be performed after junction. However, since the part will recrystallize big and rough with heating at the time of the following superplasticity forming if cold drawing of the tubing which consists of a recrystallization plate is carried out, it is not desirable. Therefore, as for the former plate at the time of tubulation, it is desirable to perform heat treatment of H2n and H3n annealed to H1n or extent which is not recrystallized. In this case, since a high processing distortion is introduced, even if a joint performs cold drawing further, this part does not cause big and rough-ization of crystal grain at the time of super-elasticity.

[0015]

[Example] Hereafter, the example of this invention is explained.

[0016] [Example 1] The example of the rolled plate zygote suitable for large-sized mold goods is explained first. A table 1 is the alloy-content presentation of the aluminum alloy used for the example.

[0017]

[A table 1]

合金	Si	Fe	Cu	Mg	Mn	Cr	Zn	Ti	Zr
1	0.03	0.03	Tr	4.73	0.74	0.12	0.01	0.01	Tr
2	0.03	0.03	1.51	2.33	0.01	0.22	5.69	0.03	Tr

[0018] By the usual manufacture approach, an alloy 1 is an alloy equivalent to 5083 about the alloy of the chemical entity of a table 1, and this was produced to H18 material of 2.0mm of board thickness. Moreover, an alloy 2 is an alloy equivalent to 7475, and produced this to W material of 2.0mm of board thickness. The blank with a width of face [of 100mm] and a die length of 100mm was produced from these plates, it joined with the various conjugation methods shown with a rolling direction turning into a longitudinal direction in a table 2, and the 100mmx200mm plate was obtained. After removing the weld flash and the reinforcement of a joint and making this joint plate flat, the test piece with a width of face [of 10mm] and a parallel part die length of 30mm was produced so that a joint might become in the center of a test piece longitudinal direction, and the super-elasticity tension test was performed with the temperature and rate of strain which are shown in a table. In addition, the trial with the same said of the former plate which has not been joined for a comparison was performed. The result is shown in a table 2.

[0019]

[A table 2]

合金	接合法	加温後の結晶粒径		超塑性成形温度	歪み速度	超塑性伸び(%)	備考
		元板部	接合部				
1	FSW	12μm	6μm	500℃	1×10^{-3}	350	発明例
	DCパット		16μm			290	発明例
	TIG溶接		150μm (凝固組織)			15	比較例
	元板		--			320	比較例
2	FSW	18μm	12μm	530℃	1×10^{-4}	890	発明例
	TIG溶接		200μm (凝固組織)			10	比較例
	元板		--			860	比較例

[0020] As shown in a table, the diameter of crystal grain of the test piece which carried out TIG arc welding is also small what carried out solid state welding to super-elasticity elongation having almost disappeared, and it has a former plate which has not joined a super-elasticity property, either, an EQC, or level which improved. therefore -- according to this invention -- double width -- the huge aluminum alloy plate for superplastic forming can be obtained, and it becomes possible to make a large-sized cast from superplastic forming.
[0021] [Example 2] The example of tubing for superplastic forming is explained below. A table 3 is the alloy-content presentation of the aluminum alloy used for the example 2.
[0022]
[A table 3]

合金	Si	Fe	Cu	Mg	Mn	Cr	Zn	Ti	Zr
6	0.03	0.03	Tr	4.73	0.74	0.12	0.01	0.01	Tr
7	0.03	0.03	1.51	2.33	0.01	0.22	5.69	0.03	Tr
8	0.62	0.21	0.31	1.01	0.03	0.13	0.01	0.01	Tr

[0023] The alloy 6 (about [5083]) of a table 3 was made into H24 material of 2.0mm of board thickness by the usual process. Moreover, it considered as W material of 2.00mm of board thickness to which 230 degrees C of alloys 7 (about [7475]) were annealed by the usual process for 5 hours, and they carried out overaging. It joined with the conjugation method which indicates that these plates become diameter die length of 300mm of 30mm to bending and a table 4, and considered as the circular pipe. Moreover, T-four material extrusion pipe with a diameter of 30mm was manufactured using the alloy 8 (about [6061]). It supplied to the 500-degree C air furnace which is equivalent to super-elasticity temperature about these, and the crystal grain of former Itabe after 15-minute maintenance and a joint was measured. Subsequently, superplastic forming which carries out tube expanding to 60mm with pneumatic pressure using the metal mold shown in drawing 2 was carried out, and the moldability was evaluated. The result is shown in a table 4.
[0024]
[A table 4]

合金	接合法	加温後の結晶粒径		超塑性成形温度	成形圧力	外径増加	備考
		元板部	接合部				
6	FSW	12μm	6μm	500℃	5気圧	60φ	発明例
	電縫管		16μm			60φ	発明例
	TIG溶接		150μm（凝固組織）			溶接部で破断	比較例
7	FSW	18μm	12μm	530℃	1気圧	60φ	発明例
	TIG溶接		200μm（凝固組織）			溶接部で破断	比較例
8	元材（押出パイプ）	54μm	--	500℃	1気圧	42φで破断	比較例

[0025] Since super-elasticity elongation has almost disappeared by what carried out TIG arc welding to the with a% [of -> with a diameter of 30mm 60mm outer diameters] of 100 increment having been possible for what is depended on this invention as shown in a table, it has fractured by the joint. Moreover, with extrudate, the cold drawing is carried out in the

case of tube manufacturing, and for this reason, detailed-izing of crystal grain is inadequate, and it has fractured by the middle, without as a result obtaining sufficient tube expanding.

[0026]

[Effect of the Invention] as explained in full detail above, without it loses the super-elasticity property of a former plate according to this invention -- double width -- it becomes possible to really fabricate also by large-sized thing like the hull of a leisure boat by the superplastic forming which can obtain a huge plate, therefore has big forming performance. Moreover, if tubing by this invention is used, it will become possible to manufacture tubing which a diameter is large and is different, or tubing which has a complicated cross section. Taking advantage of the imprint nature on the front face of a plate which is furthermore the description of superplastic forming, manufacture of the large-sized building-materials panel of a complicated surface pattern or an ornament column can also be performed easily.

Figure 1

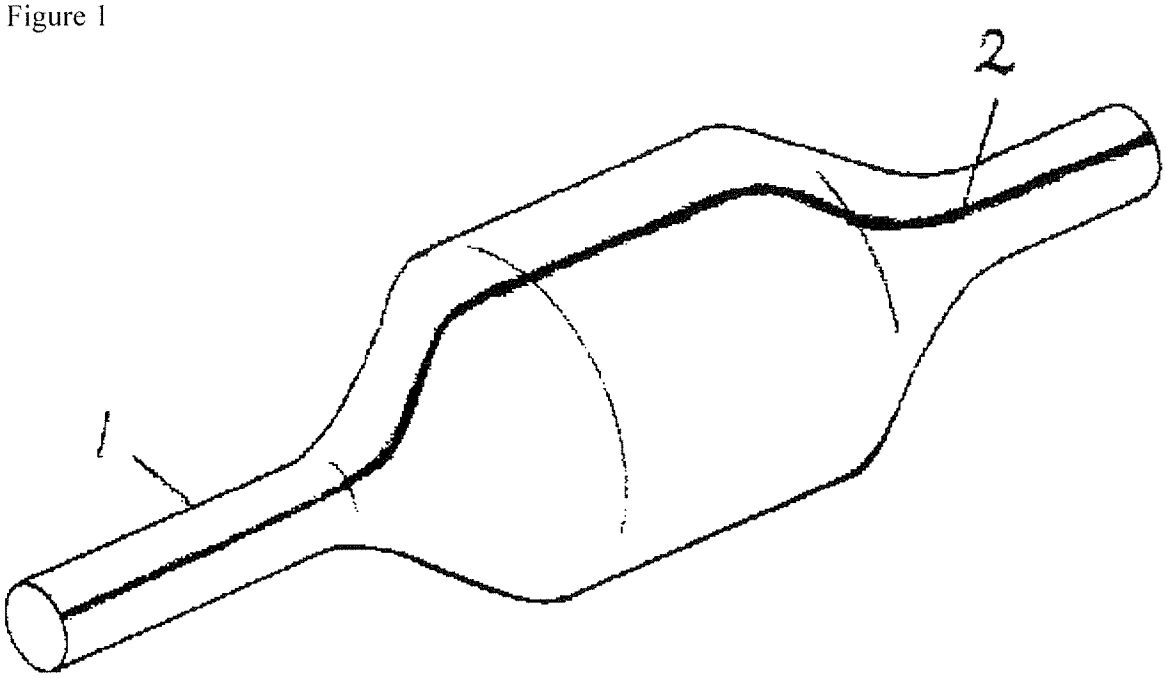
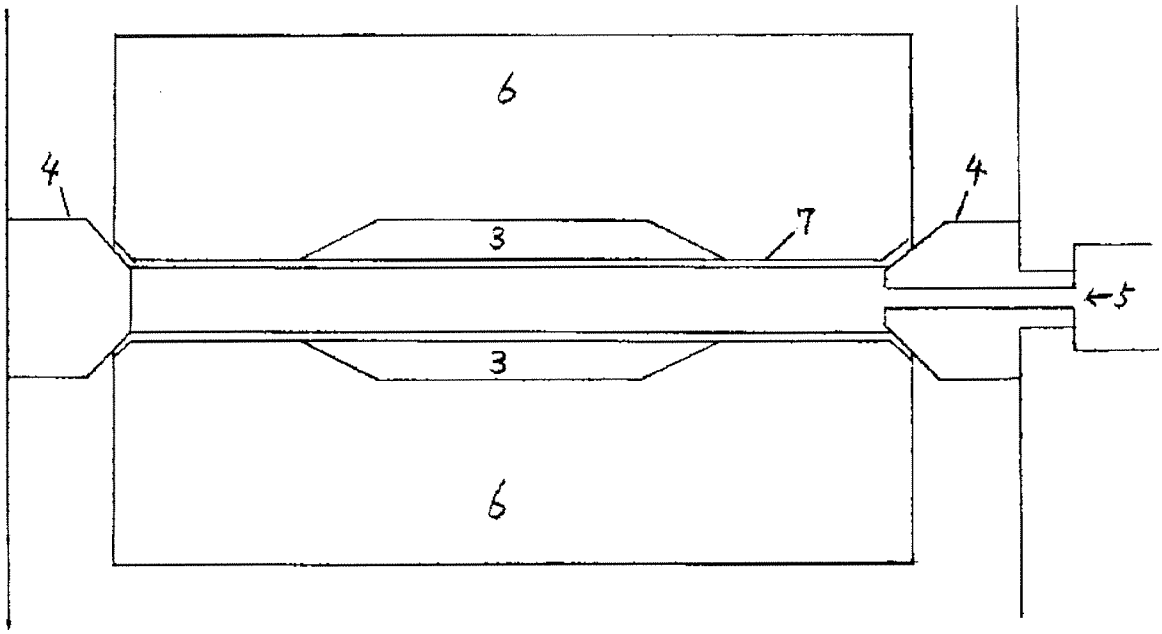


Figure 2



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[Description of the Prior Art] In recent years, various researches are made about the

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[0004]

[Problem(s) to be Solved by the Invention] However, although the rolled plate large-sized as a raw material was required in order to obtain large-sized mold goods by the superplastic forming mentioned above, the large-sized rolled plate, especially the double-width rolled plate had the constraint on a facility actually, and there was a limitation in double width-ization. Although it is possible as a cure for this to usually weld a plate, since it once dissolves and a weld zone serves as solidification structure, the super-elasticity property of this part has the problem of disappearing thoroughly. Moreover, since superplastic forming is generally based on blow molding, if a crack and fracture have arisen by poor welding even in the piece place, air leakage will occur and shaping of it will become impossible. Therefore, double-width-izing by welding is impossible.

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[Means for Solving the Problem] The joint was not dissolution solidification structure but solid state welding wholeheartedly about the conjugation method which does not check a

super-elasticity property as a result of research examination, and by giving a lot of possible processing distortion to a joint, detailed crystal grain was obtained with heating at the time of superplastic forming, and the artificer had, examined the ingredient with which the super-elasticity property of a joint does not fall substantially, and the combination of the junction approach, and resulted in the following invention.
[0008] That is, the super-elasticity aluminum alloy rolled plate comrade of this invention is aluminum alloy tubing for superplastic forming with which are the double width aluminum alloy plate for superplastic forming characterized by carrying out solid state welding, and it comes to carry out solid state welding of the super-elasticity aluminum alloy rolled plate. It is the super-elasticity Plastic solid which are claim 1 characterized by using friction stirring junction, flash butt welding, DC butt welding, and electric resistance welding as solid state welding, and super-elasticity aluminum alloy material according to claim 2, and furthermore comes to carry out superplastic forming of the zygote according to claim 1 or 2.
[0009]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained.
[0010] First, the superplastic materials in this invention are explained. Although the ingredient used for this invention is altogether applicable if it is an aluminum alloy in which a super-elasticity property is shown, generally they are an aluminum-Mg system, an aluminum-Zn-Mg system, an aluminum-Zn-Mg-Cu system, an aluminum-Cu system, an aluminum-Li system, an aluminum-Mg-Si system, an aluminum-Si system, etc., and 5083, 7475, and 2004 grades are specifically fundamentally suitable for it. By generally making a recrystallization grain detailed, the super-elasticity aluminum alloy has acquired the super-elasticity property, and its 30 micrometers or less are desirable as crystal grain size. Moreover, two kinds, the static recrystallization type (5083, 7475 grades) which makes crystal grain detailed before usually performing super-elasticity deformation, and the continuous recrystallization type made to recrystallize dynamically during super-elasticity deformation, are known, and it can use both these static recrystallization type and dynamic recrystallization type in this invention. Even if the ingredient of the type made detailed with static recrystallization performs grain-refining processing at the process which manufactures a rolled plate beforehand, it sets the diameter of crystal grain to 40 micrometers or less. Or it is made to make it recrystallize with heating at the time of superplastic forming as H2n which carried out softening to extent of 40% or more of reduction of sectional area from which cold rolling processing is carried out, and it considers as H1n material, or recrystallization does not produce it, or an H3n condition. By the type which carries out dynamic recrystallization, it is required for the cold rolling plate (H1n) of 40% or more of rates of cold rolling, and extent from which recrystallization does not produce it to consider as H2n or H3n condition which carried out softening, and, thereby, dynamic recrystallization arises and makes it detailed during deformation with the dynamic distortion at the time of super-elasticity deformation, and the relation of temperature.
[0011] The conjugation method in this invention is explained below. As for the conjugation method used by this invention, it is indispensable that it is a solid-state-welding method. Here, it is applicable, if a fusion zone is discharged in a junction process and the junction interface serves as solid state welding as a result, even if a solid-state-welding method means the conjugation method with which solidification structure does not remain in a joint and the dissolution arises in a junction interface temporarily like a flash-butt-welding method. However, in spot welding and spot welding like projection welding, since it is not joined and air leakage is started from here between welding point comrades at the time of shaping, it is not desirable. Solid phase stirring junction (FSW), flash plate vat junction, DC vat junction, electric resistance welding, etc. are common, and, more specifically, especially solid phase stirring junction (FSW) is suitable from a high distortion being introduced into a joint and a

super-elasticity property improving.
[0012] The operation by this invention is as follows. Since it becomes the solidification structure where the joint was once fused in the case of fused junction, crystal grain makes it big and rough, and a super-elasticity property is completely lost. On the other hand, even if in the case of solid state welding melting does not happen or it once fuses, molten metal is discharged from a joint, and as a result, the condition that big and rough crystal grain does not exist is acquired by the joint. Furthermore, a high distortion is introduced from receiving strong plastic working in the condition of an elevated temperature [near / a junction interface and / its], therefore detailed recrystallization of the joint is carried out, or it is minutely recrystallized with heating at the time of superplastic forming at least. That is, the super-elasticity property of a joint will be maintained, without falling, or will improve. Consequently, the zygote by this invention becomes possible [giving sufficient shaping by superplasticity forming]. Therefore, by joining two or more narrow-width rolled plates, enough magnitude large-scale super-elasticity plates can be obtained, and it becomes possible by carrying out superplastic forming of this to really fabricate large-scale Plastic solids, such as a leisure boat hull. Or 5083, and the extrusion and drawing like 7475 are able to make tubing also from a difficult alloy system easily by incurvating a rolled plate and joining. And since the super-elasticity property is not lost, it becomes possible to manufacture the tubular Plastic solid of a complicated configuration easily by carrying out tube expanding of this tubing by superplastic forming using variant cross-section metal mold.
[0013] In addition, there is no generating of the clearance from which a gas although a gas will leak at the time of superplastic forming if it is easy to produce a crack etc. in a joint as a weld flaw in fused junction and there is such a crack, and fabricating becomes difficult, since it joins putting a pressure high in solid state welding leaks, and there is no problem at the time of such shaping.
[0014] Moreover, in manufacture of tubing, cold drawing may be performed after junction. However, since the part will recrystallize big and rough with heating at the time of the following superplasticity forming if cold drawing of the tubing which consists of a recrystallization plate is carried out, it is not desirable. Therefore, as for the former plate at the time of tubulation, it is desirable to perform heat treatment of H2n and H3n annealed to H1n or extent which is not recrystallized. In this case, since a high processing distortion is introduced, even if a joint performs cold drawing further, this part does not cause big and rough-ization of crystal grain at the time of super-elasticity.
[0015]
[Example] Hereafter, the example of this invention is explained.
[0016] [Example 1] The example of the rolled plate zygote suitable for large-sized mold goods is explained first. A table 1 is the alloy-content presentation of the aluminum alloy used for the example.
[0017]
[A table 1]

合金	Si	Fe	Cu	Mg	Mn	Cr	Zn	Ti	Zr
1	0.03	0.03	Tr	4.73	0.74	0.12	0.01	0.01	Tr
2	0.03	0.03	1.51	2.33	0.01	0.22	5.69	0.03	Tr

[0018] By the usual manufacture approach, an alloy 1 is an alloy equivalent to 5083 about the alloy of the chemical entity of a table 1, and this was produced to H18 material of 2.0mm of board thickness. Moreover, an alloy 2 is an alloy equivalent to 7475, and produced this to W material of 2.0mm of board thickness. The blank with a width of face [of 100mm] and a die

length of 100mm was produced from these plates, it joined with the various conjugation methods shown with a rolling direction turning into a longitudinal direction in a table 2, and the 100mmx200mm plate was obtained. After removing the weld flash and the reinforcement of a joint and making this joint plate flat, the test piece with a width of face [of 10mm] and a parallel part die length of 30mm was produced so that a joint might become in the center of a test piece longitudinal direction, and the super-elasticity tension test was performed with the temperature and rate of strain which are shown in a table. In addition, the trial with the same said of the former plate which has not been joined for a comparison was performed. The result is shown in a table 2.

[0019]

[A table 2]

合金	接合法	加温後の結晶粒径		超塑性成形温度	歪み速度	超塑性伸び(%)	備考
		元板部	接合部				
1	FSW	12μm	6μm	500℃	1×10^{-3}	350	発明例
	DCパット		16μm			290	発明例
	TIG溶接		150μm (凝固組織)			15	比較例
	元板		--			320	比較例
2	FSW	18μm	12μm	530℃	1×10^{-4}	890	発明例
	TIG溶接		200μm (凝固組織)			10	比較例
	元板		--			860	比較例

[0020] As shown in a table, the diameter of crystal grain of the test piece which carried out TIG arc welding is also small what carried out solid state welding to super-elasticity elongation having almost disappeared, and it has a former plate which has not joined a super-elasticity property, either, an EQC, or level which improved. therefore -- according to this invention -- double width -- the huge aluminum alloy plate for superplastic forming can be obtained, and it becomes possible to make a large-sized cast from superplastic forming.

[0021] [Example 2] The example of tubing for superplastic forming is explained below. A table 3 is the alloy-content presentation of the aluminum alloy used for the example 2.

[0022]

[A table 3]

合金	Si	Fe	Cu	Mg	Mn	Cr	Zn	Ti	Zr
6	0.03	0.03	Tr	4.73	0.74	0.12	0.01	0.01	Tr
7	0.03	0.03	1.51	2.33	0.01	0.22	5.69	0.03	Tr
8	0.62	0.21	0.31	1.01	0.03	0.13	0.01	0.01	Tr

[0023] The alloy 6 (about [5083]) of a table 3 was made into H24 material of 2.0mm of board thickness by the usual process. Moreover, it considered as W material of 2.00mm of board thickness to which 230 degrees C of alloys 7 (about [7475]) were annealed by the usual process for 5 hours, and they carried out overaging. It joined with the conjugation method which indicates that these plates become diameter die length of 300mm of 30mm to bending and a table 4, and considered as the circular pipe. Moreover, T-four material extrusion pipe with a diameter of 30mm was manufactured using the alloy 8 (about [6061]).

It supplied to the 500-degree C air furnace which is equivalent to super-elasticity temperature about these, and the crystal grain of former Itabe after 15-minute maintenance and a joint was measured. Subsequently, superplastic forming which carries out tube expanding to 60mm with pneumatic pressure using the metal mold shown in drawing 2 was carried out, and the moldability was evaluated. The result is shown in a table 4.
[0024]
[A table 4]

合金	接合法	加温後の結晶粒径		超塑性成形温度	成形圧力	外径増加	備考
		元板部	接合部				
6	ＦＳＷ	１２μｍ	６μｍ	５００℃	５気圧	６０φ	発明例
	電縫管		１６μｍ			６０φ	発明例
	ＴＩＧ溶接		１５０μｍ（凝固組織）			溶接部で破断	比較例
7	ＦＳＷ	１８μｍ	１２μｍ	５３０℃	１気圧	６０φ	発明例
	ＴＩＧ溶接		２００μｍ（凝固組織）			溶接部で破断	比較例
8	元材（押出パイプ）	５４μｍ	－－	５００℃	１気圧	４２φで破断	比較例

[0025] Since super-elasticity elongation has almost disappeared by what carried out TIG arc welding to the with a% [of -> with a diameter of 30mm 60mm outer diameters] of 100 increment having been possible for what is depended on this invention as shown in a table, it has fractured by the joint. Moreover, with extrudate, the cold drawing is carried out in the case of tube manufacturing, and for this reason, detailed-izing of crystal grain is inadequate, and it has fractured by the middle, without as a result obtaining sufficient tube expanding.
[0026]
[Effect of the Invention] as explained in full detail above, without it loses the super-elasticity property of a former plate according to this invention -- double width -- it becomes possible to really fabricate also by large-sized thing like the hull of a leisure boat by the superplastic forming which can obtain a huge plate, therefore has big forming performance. Moreover, if tubing by this invention is used, it will become possible to manufacture tubing which a diameter is large and is different, or tubing which has a complicated cross section. Taking advantage of the imprint nature on the front face of a plate which is furthermore the description of superplastic forming, manufacture of the large-sized building-materials panel of a complicated surface pattern or an ornament column can also be performed easily.

CLAIMS

[Claim(s)]
[Claim 1] The double width aluminum alloy plate for superplastic forming characterized by carrying out solid state welding of the super-elasticity aluminum alloy rolled plate comrade.
[Claim 2] Aluminum alloy tubing for superplastic forming with which it comes to carry out solid state welding of the super-elasticity aluminum alloy rolled plate.
[Claim 3] Claim 1 characterized by using friction stirring junction, flash butt welding, DC butt welding, and electric resistance welding as solid state welding, and super-elasticity aluminum alloy material according to claim 2.
[Claim 4] The super-elasticity Plastic solid which comes to carry out superplastic forming of the zygote according to claim 1 or 2.

Figure 1

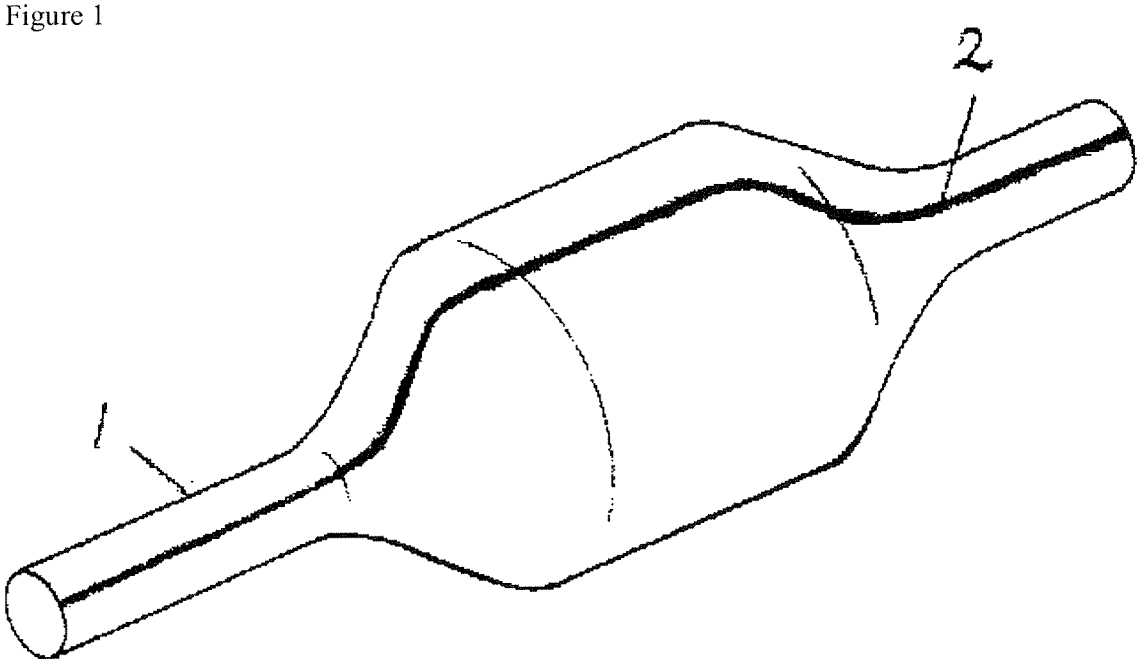

Figure 2